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Original Article

THE EFFECT OF PROTEIN AND LOW MOLECULAR WEIGHT SURFACTANTS ON SPRAY DRYING OF GUAVA POWDER

KAMLESH KUMAR MAURYA[1], ANIL KUMAR CHAUHAN[2], MUKESH KUMAR MAURYA[3] & PRADEEP JOLIYA[4]

[1, 2] Centre of Food Science and Technology, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India

[3, 4]Department of Agricultural Economics, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India

ABSTRACT

The effects of proteins and low molecular weight surfactants (LMS) on spray drying of guava powder have been studied. Guava fruit were selected as sugar rich foods and sodium caseinate (NaCas) was selected as a model protein. Sodium stearoyl lactylate (SSL) and Polysorbate 80 (Tween-80) were chosen as surfactants. Both NaCas: Tween-80 and NaCas:SSL was (0.5:0.05) was required. concentration respectively. The surface protein coverage guava powder in sugar–protein systems were very sensitive in the presence of low molecular weight surfactants due to being below the critical micelle concentration of NaCas. By adding protein-LMS good quality of powder obtained without stickness. The spray dried powders produced in this study were extremely stable at room temperature and could be reconstituted after blending with room temperature water.

KEYWORDS: Sugar-Rich Guava Fruits, Sodium Caseinate, Low Molecular Weight Surfactants, Sodium Stearoyl Lactylate (SSL), Polysorbate-80 (Tween-80), Surface Protein Coverage Spray Drying

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INTRODUCTION

Guava *(Psidiumguajava L.*) is a native fruit from American tropics. The fruit has about 83 per cent moisture and is an excellent source of pectin but has low energy (66 cal/100 g) and protein content (1%). The fruit is rich in minerals like phosphorous (23-37 mg/100 g), calcium (14-30 mg/100 g), iron (0.6-1.4 mg/100g) as well as vitamins like niacin, pathogenic acid, thiamine, riboflavin, vitamin A and C, Omega-3 and -6 poly unsaturated fatty acids and especially high levels of dietary fiber **(Chin and Yong, 1980).**

Spray-dried powders are economical to produce compared to other processes such as freeze-drying **(Knorr, 1998).** Spray-drying has many applications, particularly in the food, pharmaceutical and agrochemical industries **(Vega et al., 2005).**Guava powder with maltodexrine was much hard and short shelf life than guava powder with SSL and Tween -80. So these surfactants are much cheaper and good additive.

There are less sticking and corrosion problems in spray drying if the materials do not contact the equipment wall until it is dry (**Gupta, 1978**). It is a powerful tool for delivering cost effective, high quality products (**Masters *et al*., 1997**). Various technological adjuvants, including maltodextrin, modified starch, cyclodextrins, arabic gum and colloidal silicon dioxide, are generally added to extractive solutions before spray

drying in order to improve process performance and product quality.

Protein have very rapid film forming properties when subjected to drying air. These film resist the particle cohesive stickiness as well as to particle to wall stickiness of guava powder.

If small amount of protein add in guava powder as a smart drying aids for spray drying, protein formed a once type of film upon guava powder, which was responsible for overcoming the stickiness. It was found that the preferential migration of proteins combined with their film-forming property upon drying, is responsible for overcoming the stickiness of sugar–protein solutions **(Adhikari *et al.,* 2009).**

Small quantity of proteins is required to successfully convert sugar-rich foods into powder form. For example only 0.13% of NaCas and whey proteins are required to convert sucrose (a model sugar-rich food) into powder while >40% of maltodextrin (DE 6) is required to achieve the same yield outcome **(Jayasundera *et al.,* 2010).** Addition of such large amounts of these carriers alters the resultant powder quality and risks consumer. Used of small amount of LMS (0.05%) was 800 times less than maltodextrin,so these was more economically. In spray drying protein and LMS compete for the air- water interface of droplet **(Pugnaloni *et al.,*2004).**

MATERIALS AND METHODS

Sodium caseinate (NaCas) (Sigma–Aldrich) with a protein content of 92.9% was used as a model protein and it was used as received. Two surfactants SSL and Tween-80 were used in guava powder.SSL is an ionic surfactants while Tween-80 is non-ionic surfactants. Both the surfactants are water soluble and are suitable for oil-in-water emulsions **(McClements. 2005).** Guava *(Psidium guajava L.*) were crushed in the fruit mill **(PSF121**, **India)** and then transferred to the pulper (RI-05, India) for the pulp. Pulp was homogenized in a previously sterilized mechanical blender **(GT56, India).**

METHODS

Extraction of Pulp from Guava

Guavas were crushed in the fruit mill **(PSF121, Indi**a) and then transferred to the pulper **(RI-05, India**) for the pulp. The extraction is done for the 4-5 times to get maximum pulp. Pulp was homogenized in a previously sterilized mechanical blender **(GT56, India).** Pulp was stored in a refrigerator in a previously sterilized stainless steel container with lid for further use.

Sample Preparation

Before being dehydrated, the juice was diluted in distilled water until reaching a total soluble solid content of 12° Brix. Protein solutions were prepared by heating the solution at 45±5C and gently agitating with a magnetic stirrer. Solutions of guava pulp-protein - SSL and guava pulp-protein-Tween-80 were prepared by adding 0.05% of each surfactant to the solutions. The solutions were heated to 45±5C to ensure that all solids were completely dissolved. The solutions prepared were tested for subsequently spray-dried. Solutions of 0.5%, (w/w) NaCas were also prepared to determine the critical micelle concentration of NaCas. All prepared solution were well mixed with guava pulp with help of beater. Two type of sample was prepared (1)NaCas(0.5) +SSL(0.05%) guava pulp,(2) NaCas(0.5) +0.05% Tween-80(0.05%) (guava pulp). So two type of guava powder was obtained

Guava
⇩
Washing
⇩
Blanching
⇩
Cutting into small pieces using fruit mill
⇩
Pulping using hexacolidal fruit juice extractor
⇩
Pasteurization of guava slurry (75°C, 30 min)
⇩
Addition of water (40%)
⇩
Blending (NaCas,Tween80&SSL)
⇩
Guava slurry
⇩
Spray drying (Inlet air temperature: 180 –184°C)
⇩
(Outlet air temperature: 80-84°C)

(Feed rate: 16-18 rpm) (Air pressure: 5.1 kg/cm^2)

Guava powder
⇩
Packaging
⇩
Storage

Flow Chart for Development of Guava Powder

Powder Production

NIRO FSD 4 spray used (CFST lab. in BHU) in powder production system, rated 5 to 25 kg/h water evaporation, designed to combine spray drying . The inlet and outlet temperatures were maintained at 180 ^{0}C and 80 ^{0}C, respectively. The powders were collected from cyclone and the cylindrical part of the dryer chamber by lightly sweeping the chamber wall. Polyethylene bag packaging material was used in powder packaging. (Optimization of spray-drying experiment by ANOVA).

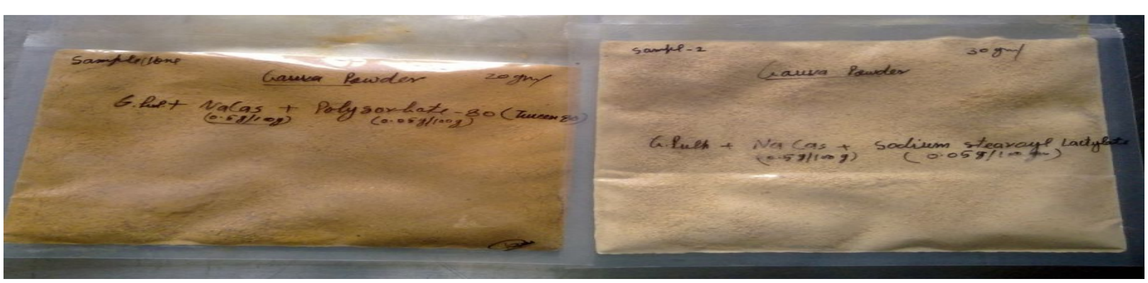

Figure 1: Guava Powder

Table 1: Specification of Spray Dryer Used in Present Study

S. No.	Particular	Specifications
1	Nozzle Type	Pressure Nozzle
2	Pressure Nozzle	Pressure Nozzle
3	Atomization Energy	Low
4	Liquid Processing Capacity per Nozzle	Medium
5	Spray Angle	Under 60°
6	Spray Shape	Full cone fine
7	Capacity for Droplet Diameter Control	Conditions Apply

Moisture

The moisture content was determined by drying the powder samples in a vacuum oven at $70C^0$ for 24h by AOAC method, 927.05 **(AOAC, 2000).** The samples were removed from the oven, cooled in a desiccators and weighed. The drying and weighing processes were repeated until constant weights were obtained.

Water Activity

Water activity or a_w the measurement of water vapor pressure generated by the free or non-chemically bound water in foods and other products. The a_w value (range: 0.00...1.00 a_w) of pure distilled water has exactly one. As temperature increases**,** $\mathbf{a_w}$ typically increases, except in some products with crystalline salt or sugar.

$$a_w = \frac{P}{P_0}$$

Where

a_w water activity

P is vapor pressure of the water in the substrate

P_0 vapor pressure of pure water at the same temperature

RESULTS AND DISCUSSIONS

The spray-drying process can produce a good quality final product with low water activity and reduce the weight, resulting in easy storage and transportation. The physico-chemical properties of the final product mainly depend on inlet temperature, air flow rate, feed flow rate, atomizer speed, types of carrier agent and their concentrations. The spray-drying process can produce a good quality final product with low water activity and reduce the weight, resulting in easy storage and transportation. During spray drying guava powder was not manufactured due to low solid and absence of a drying aid in the feed.

During powder production of guava powder good quality of guava pulp was selected and pulp was diluted to add 10% of water. Due to water flow rate is maintained and minimum chance of choked the nozzle of spray dryer. Protein–SSL and protein-Tween-80 about 0.5% and 0.05% mixture of guava pulp was taken. Good quality of non-hygroscopic, free flowing, powder was obtained after spray drying of mixture.

All the powders produced by spray drying were good appearance in irrespective of the color of the feed material. Guava powder obtained by spray dryer was stable at room temperature. .The moisture content of all the spray-dried powders were lower than that of the freeze-dried powders. Surfactant percentage which used in guava powder production

was very low than other surfactant like maltodextrin. Used of small amount of LMS (0.05%) was 800 times less than maltodextrin,so these was more economically. And both surfactants was effective to successful guava powder production.

It has also been found that significantly small quantity (compared to commonly used additives such as maltodextrins) of proteins is required to successfully convert sugar-rich foods into powder form. Controlled addition of low molecular surfactants in the sugar–protein matrix will allow quantification of surface behaviour of sugar–protein–LMS systems in powder formation process in spray-drying. By adding protein-LMS good quality of powder obtained without stickness.

Low molecular surfactants cannot be used as drying aids. They can effectively use to control the amount of protein at the surface of a droplet or a particle. Both protein and low molecular surfactants compete for the air–water interface of a droplet. Since low molecular surfactants are smaller in size compared to proteins, they are kinetically advantaged to occupy the surface of a droplet. Since they have low glass transition temperature, the low molecular surfactants cannot be used as drying aids. They can effectively used to control the amount of protein at the surface of a droplet or a particle.

It is interesting to note that in the case of guava sugar–NaCas solution, probably due to a very high concentration of protein none of these two low molecular weight surfactants was capable of displacing the proteins from the droplet surface. It can be attributed that protein molecules forced to make tight multiple layers on the surface of the droplets. The surface elemental analysis would later indicate that the surface of the droplet is super saturated with proteins. This suggests that the ability of the low molecular surfactants to displace the proteins depends on the amount of protein in the system. The low molecular weight surfactants are very effective in displacing the protein from the drop surface when the protein concentration is below the critical concentration of NaCas.

Table 2: Analysis of Moisture and Water Activity and Crude Fiber

Sample	Parameters a_w(24.5±0.5℃)	Moisture(%) wb	% Crude Fiber
NaCas(0.5) +0.05% SSL(guava powder)	0.84±0.02	3.80±0.1	3.61
NaCas(0.5) +0.05% Tween-80(guava powder)	0.16±0.00	6.56±0.02	3.60
NaCas (commercial)	3.60	5.0±0.0	
SSL (commercial)	0.36±0.01	3.7±0.2	

All values are means of three replicates with standard deviation.

The physical parameters of the powders produced are presented in above Table 2. The $\mathbf{a_w}$ values of all powders of NaCas-SSL and NaCas–Tween80 (0.05%) are within the range of $\mathbf{a_w}$ values (≈0.84) of industrially spray-dried powders .Water activity values of NaCas- SSL ($\mathbf{a_w}$ =0.84) were high than NaCas- Tween-80($\mathbf{a_w}$ 0.16). The high $\mathbf{a_w}$ values are due to the fact that these two powders were semi crystalline and the moisture was mostly free water ($\mathbf{a_w}$ 0.84) in this sample. Crude fiber content in powders of NaCas-SSL was 3.61% and powder of NaCas–Tween-80 was 3.60%.

The quality of both Powder was good but NaCas- Tween-80 powder water ($\mathbf{a_w}$ 0.16) less than NaCas- SSL water ($\mathbf{a_w}$ =0.84). So Tween-80 powder will have high shelf life than SSL containing powder. Moisture contained of spray drying powder was lower than 5%. So it is feature of good quality of powder. NaCas–SSL guava powder have low moisture content (3.80±0.01%). The moisture content of all the powder samples is well within the range, NaCas–Tween-80 (0.05%)

have high moisture content (6.56±0.02%). The moisture content of all protein containing powders was high due to higher protein content. Economically Tween-80 was cheaper surfactants than SSL,so in future we would be successfully produce lot of guava powder using this surfactants (Table 2).

CONCLUSIONS

More than 90% of amorphous guava powders were produced through spray drying with the addition of 0.05% of sodium caseinate (initial bulk concentration), respectively. This is an indication that NaCas can act as a very effective drying aid. The $\mathbf{a}_w$ values of all powders of NaCas-SSL and NaCas–Tween 80 are within the range of $\mathbf{a}_w$ values (≈0.84) of industrially spray-dried powders. Water activity values of NaCas- SSL ($\mathbf{a}_w$ =0.84) were high than NaCas- Tween-80($\mathbf{a}_w$ 0.16). NaCas–Tween-80 guava powder have high moisture content (6.56±0.02%). NaCas–SSL guava powder have low moisture content (3.80±0.01%). Crude fiber content in powders of NaCas-SSL was 3.61% and powder of NaCas–Tween80 was 3.60%.

So very small quantity of proteins and surfactant is required to successfully convert sugar-rich foods into powder form than other additive like maltodextrins. Powder was stable in room temperature and successful packaging in Metallized polyester packaging material. Addition of such a small amounts of these carriers no alters the resultant powder quality and no risks consumer disapproval and more economically.

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